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CERTIFICATION

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P: 301.424.7737

F: 301.424.2336

This is to certify that the attached English language document, identified as High-strength Aluminum Alloy Clad Material Used for High-temperature Molding Purposes, is a true and accurate translation of the corresponding Japanese language document to the best of our knowledge and belief.

Executed this 31st day
of July, 2000

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(12) Japan Patent Office (JP)

(11) Kokai Patent No. Hei 5[1993]-25573

(51) Int. Cl.^{5}: C 22 C 21/00
B 23 K 20/04
C 22 C 21/06

(43) Publication Date: February 2, 1993

Examination Request: Not requested
Number of Claims: 4
Total Pages: 5

(21) Application No.: Hei 3[1991]-204738

(22) Application Date: July 19, 1991

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(54) Title of the invention

High-strength aluminum alloy clad material used for high-temperature molding purposes

(57) Summary

Objective: An aluminum alloy clad material which exhibits excellent high-temperature moldability and strength, and which is suitable as components of structures which are used in oceanic atmospheres (e.g., ships, etc.)

Constitution: A high-strength aluminum alloy clad material used for high-temperature molding purposes which is constituted by a core material of an Al alloy which includes 0.5-7.5% of Mg and one, two, or more types of elements selected from among Cr, Mn, Zr, Ti, Fe, Ni, Cu, and Zn and a skin material of an Al alloy which includes 0.1-2.5% of Mn, ≤ 1% of Fe, ≤ 1% of Si, and one, two, or more types of elements selected from among Mg, Cu, Cr, Zr, and Ni and which is obtained by cladding either or both planes of said core material.

Claims

1. A high-strength aluminum alloy clad material used for high-temperature molding purposes which is obtained by cladding on either or both planes of a core material which includes 0.5-7.5 wt% of Mg as an indispensable element, one, two, or more types selected from among 0.03-0.55 wt% of Cr, 0.03-2.5 wt% of Mn, 0.03-0.25 wt% of Zr, 0.005-0.35 wt% of Ti, 0.03-0.5 wt% of Fe, and 0.03-1.5 wt% of Ni optionally, and a balance of Al a skin material constituted by 0.1-2.5 wt% of Mn, ≤ 1% of Si, ≤ 1% of Fe, and a balance of Al.

2. A high-strength aluminum alloy clad material used for high-temperature molding purposes which is obtained by cladding on either or both planes of a core material which includes 0.5-7.5 wt% of Mg as an indispensable element, one, two or more types selected from among 0.03-0.55 wt% of Cr, 0.03-2.5 wt% of Mn, 0.03-0.25 wt% of Zr, 0.005-0.35 wt% of Ti, 0.03-0.5 wt% of Fe, and 0.03-1.5 wt% of Ni optionally, and a balance of Al a skin material constituted by 0.1-2.5 wt% of Mn, ≤ 1% of Si, ≤ 1% of Fe, one, two, or more types selected from among 0.1-1 wt% of Cu, 0.1-2 wt% of Mg, 0.1-0.3 wt% of Cr, 0.1-0.3 wt% of Zr, and 0.1-1.5 wt% of Ni, and a balance of Al.

3. A high-strength aluminum alloy clad material used for high-temperature molding purposes which is obtained by cladding on either or both planes of a core material which includes 0.5-7.5 wt% of Mg as well as either or both types selected from between 0.01-0.5 wt% of Cu and 0.02-2.5 wt% of Zn as indispensable elements, one, two or more types selected from among 0.03-0.55 wt% of Cr, 0.03-2.5 wt% of Mn, 0.03-0.25 wt% of Zr, 0.005-0.35 wt% of Ti, 0.03-0.5 wt% of Fe, and 0.03-1.5 wt% of Ni optionally, and a balance of Al a skin material constituted by 0.1-2.5 wt% of Mn, ≤ 1% of Si, ≤ 1% of Fe, and a balance of Al.

4. A high-strength aluminum alloy clad material used for high-temperature molding purposes which is obtained by cladding on either or both planes of a core material which includes 0.5-7.5 wt% of Mg as well as either or both types selected from between 0.01-0.5 wt% of Cu and 0.02-2.5 wt% of Zn as indispensable elements, one, two or more types selected from among 0.03-0.55 wt% of Cr, 0.03-2.5 wt% of Mn, 0.03-0.25 wt% of Zr, 0.005-0.35 wt% of Ti, 0.03-0.5 wt% of Fe, and 0.03-1.5 wt% of Ni optionally, and a balance of Al a skin material constituted by 0.1-2.5 wt% of Mn, ≤ 1% of Si, ≤ 1% of Fe, one, two, or more types selected from among 0.1-1 wt% of Cu, 0.1-2 wt% of Mg, 0.1-0.3 wt% of Cr, 0.1-0.3 wt% of Zr, and 0.1-1.5 wt% of Ni, and a balance of Al.

Detailed explanation of the invention

[0001]
(Industrial application fields of the invention)

The present invention concerns an aluminum alloy clad material which exhibits excellent high-temperature moldability and strength, and which is suitable as a material which is molded by means of a high-temperature operation and then used directly or after having further been subjected to a surface treatment, in particular, as components of structures which are used in oceanic atmospheres (e.g., ships, etc.)

[0002]
(Prior art and its problems)

Outer frames of ships, especially relatively compact fishing boats, leisure boats, etc., have often been obtained by press-molding steel sheets and by applying coating films to them. The steel sheets, however, tend to be plagued with coating film scratches, and their corrosion resistances are low after [the coating films have become] peeled, which mandates periodic recoating operations. In recent years, therefore, boats which use FRP ship frames have become increasingly popular. It is difficult, however, to scrap these FRP ship frames after the ships have reached the end of their useful lives, and abandoned and unattended ships on sea shores, etc. have led to conspicuous environmental pollution problems.

[0003]
(Problems to be solved by the invention)

It is against the aforementioned backdrop that aluminum sheet materials, whose corrosion resistance is superior to those of steel sheets and whose scrappability and recyclability are superior to those of FRPs, have garnered attention as ship frame structural materials for these ships. Al-Mg alloys, which exhibit

excellent corrosion resistance, strength, and moldability, are often used as such structural components which are exposed to oceanic atmospheres. The moldability of aluminum structural materials, on the other hand, generally tends to be inferior to those of steel sheets, which problematizes the determination of product shapes. The hot roll molding or high-temperature molding techniques have therefore come to be contemplated as techniques for molding aluminum sheet materials into more complex shapes. Regarding such a technique, a molding material or a mold is partially or entirely heated within a temperature range of 100-500°C, and a molding operation is performed while the moldability of the material is being enhanced. This technique is suitable for molding a component which must meet an advanced processing requirement, and in addition to an ordinary press processing operation, bulge molding operations which utilize air or liquid pressures have been contemplated for such high-temperature molding purposes. No male molds are required in such methods in that air or liquid pressures are employed as pressurizing media, and another advantage lies in an improved molding limit in that the material is deformed homogeneously. When the aforementioned Al-Mg alloy is subjected to a high-temperature molding operation, however, the enrichment and oxidation of the Mg atom on the surface become unavoidable, resulting in the manifestation of a greenish-black color, which is undesirable in that the physical appearance becomes tarnished. When a coating film is formed, too, the contiguity of the coating film is adversely affected by this oxidation layer, as a result of which the corrosion resistance of the product deteriorates. Such an oxidation film must be removed chemically or mechanically, thus impeding productivity. The generation of this oxidation film is affected by the temperature and processing time, and it tends to become especially problematic in a hydraulic press molding operation or bulge processing operation. In response to these problems, the present inventors have developed a high-strength aluminum alloy clad material which is used for a high-temperature molding operation and which is suitable as a component of relatively compact ships (e.g., outer panels, etc.) which are molded at high temperatures.

[0004]

(Mechanism for solving the problems)

A high-strength aluminum alloy clad material used for high-temperature molding purposes which is obtained by cladding on either or both planes of a core material which includes 0.5-7.5 wt% of Mg as an indispensable element, one, two, or more types selected from among 0.03-0.55 wt% of Cr, 0.03-2.5 wt% of Mn, 0.03-0.25 wt% of Zr, 0.005-0.35 wt% of Ti, 0.03-0.5 wt% of Fe, and 0.03-1.5 wt% of Ni optionally, and a balance of Al a skin material constituted by 0.1-2.5 wt% of Mn, ≤ 1% of Si, ≤ 1% of Fe, and a balance of Al is specified in Claim 1, whereas a high-strength aluminum alloy clad material used for high-temperature molding purposes which is obtained by cladding on either or both planes of a core material which includes 0.5-7.5 wt% of Mg as an indispensable element, one, two or more types selected

from among 0.03-0.55 wt% of Cr, 0.03-2.5 wt% of Mn, 0.03-0.25 wt% of Zr, 0.005-0.35 wt% of Ti, 0.03-0.5 wt% of Fe, and 0.03-1.5 wt% of Ni optionally, and a balance of Al a skin material constituted by 0.1-2.5 wt% of Mn, ≤ 1% of Si, ≤ 1% of Fe, one, two, or more types selected from among 0.1-1 wt% of Cu, 0.1-2 wt% of Mg, 0.1-0.3 wt% of Cr, 0.1-0.3 wt% of Zr, and 0.1-1.5 wt% of Ni, and a balance of Al is specified in Claim 2, whereas a high-strength aluminum alloy clad material used for high-temperature molding purposes which is obtained by cladding on either or both planes of a core material which includes 0.5-7.5 wt% of Mg as well as either or both types selected from between 0.01-0.5 wt% of Cu and 0.02-2.5 wt% of Zn as indispensable elements, one, two or more types selected from among 0.03-0.55 wt% of Cr, 0.03-2.5 wt% of Mn, 0.03-0.25 wt% of Zr, 0.005-0.35 wt% of Ti, 0.03-0.5 wt% of Fe, and 0.03-1.5 wt% of Ni optionally, and a balance of Al a skin material constituted by 0.1-2.5 wt% of Mn, ≤ 1% of Si, ≤ 1% of Fe, and a balance of Al is specified in Claim 3, whereas a high-strength aluminum alloy clad material used for high-temperature molding purposes which is obtained by cladding on either or both planes of a core material which includes 0.5-7.5 wt% of Mg as well as either or both types selected from between 0.01-0.5 wt% of Cu and 0.02-2.5 wt% of Zn as indispensable elements, one, two or more types selected from among 0.03-0.55 wt% of Cr, 0.03-2.5 wt% of Mn, 0.03-0.25 wt% of Zr, 0.005-0.35 wt% of Ti, 0.03-0.5 wt% of Fe, and 0.03-1.5 wt% of Ni optionally, and a balance of Al a skin material constituted by 0.1-2.5 wt% of Mn, ≤ 1% of Si, ≤ 1% of Fe, one, two, or more types selected from among 0.1-1 wt% of Cu, 0.1-2 wt% of Mg, 0.1-0.3 wt% of Cr, 0.1-0.3 wt% of Zr, and 0.1-1.5 wt% of Ni, and a balance of Al is specified in Claim 4.

[0005]

(Functions)

The reasons for limiting the alloy components in the present invention will be explained below. First, the alloy composition of the core material will be explained. The Mg improves moldability by improving material strength and rollability while being solid-solubilized in said material. When the material is heated at a high temperature, in particular, its homogeneous deformation is effectively facilitated during its molding operation, as a result of which the molding limit is improved. The static strengths of the obtained product, furthermore, are enhanced, as a result of which its deformation by an external force can be prevented, and the temporal variation of a case where the ship frame, etc. are exposed to an external pressure over an extended period of time (e.g., creep deformation, etc.) is effectively prevented as well. The corrosion resistance of the material, furthermore, is effectively improved when the skin material of the objective product of the present invention is scratched, etc. due to environmental factors, etc. These effects are insufficient when its addition ratio is lower than 0.5 wt%, whereas when it exceeds 7.5 wt%, a crude Al-Mg compound is generated within the material, as a result of which the moldability and corrosion

resistance deteriorate. The Cu and Zn generate microscopic compounds together with the Mg, based on which the moldability of the material is improved, which is in turn attributable to its improved strength and rollability. The corrosion resistance of the material, however, tends to diminish slightly under the pervasion of either element, and in the case of a material whose core material corrosion resistance is critical, it is desirable to decide to add or not to add them in consideration of the shape and application environments. In cases where their addition ratios are below their respective lower limits, a significantly improved moldability cannot be expected, whereas in cases where their upper limits are exceeded, the clad material resistance significantly deteriorates. Cr, Mn, Zr, Ti, Fe, and Ni all form microscopic compounds within the material together with Al, as a result of which a very fine material texture is generated, and strength and moldability are improved while the corrosion resistance of the material is concomitantly improved. One, two, or more types selected from among these elements should therefore be added. These effects are insufficient in cases where their addition ratios are below their respective lower limits, whereas crude compounds are generated within the material, accompanied by moldability deterioration, in cases where they exceed their respective upper limits. Regarding elements to be internalized other than the aforementioned ones, Si is a main impurity element, and it is desirable to minimize the internalization ratio of Si in that it forms an Mg-Si compound together with Mg during an alloy smelting operation, as a result of which the effective addition ratio of the Mg diminishes, accompanied by a corrosion resistance deterioration. Lowering the Si internalization ratio, however, entails an elevated purity of the matrix metal as well as increased production cost. It is undesirable, therefore, to lower the Si internalization ratio more than necessary from an industrial point of view. In consideration of these factors, the Si internalization ratio should be designated at 0.5 wt% or below. Regarding other quantitatively minuscule elements, the performances of the present invention remain unaffected adversely if their respective internalization ratios are limited to 0.5 wt% or less. Quantitatively minuscule elements such as Ba, B, etc., which may be added for the purpose of improving the smeltability, and the misch metal, etc., which may be added for improving the moldability, may therefore be added within ranges of 0.05 wt% or less. The pervasions of other elements which have migrated during a manufacturing process are permissible so long as their ratios are 0.5 wt% or below.

[0006]

Next, the alloy components of the skin material will be discussed. It is fundamentally desirable for the skin material to be constituted by a pure Al material from the standpoint of preventing the formation of an oxidation film, but when a pure Al skin material is clad, the strength and moldability of the material tend to deteriorate. It has been discovered that, in order to minimize strength losses of the material of the present invention due to cladding, an Al-Mn material is suitable in that it exerts no adverse effects on the growth of an oxidation film at a high temperature and that its strength is higher than that of the pure Al[-

based] alloy. Not only is the Mn effective for improving normal-temperature strength, but, when a high-temperature molding operation is carried out, the strain rate sensitivity index of the deformation stress (m value) is also elevated as a result of its solid solubilization into the material, as a result of which homogeneous deformation is facilitated and the molding limit is improved. The present inventors have also discovered that Mn exerts an effect of inhibiting the diffusion of Mg within the core material into the skin material during a high-temperature molding operation. These effects are insufficient when the Mn content is lower than 0.1 wt%, whereas when it exceeds 2.5 wt%, crude crystals are deposited within the material during a casting operation, as a result of which the likelihood of moldability loss of the material is increased. Fe and Si are included as main impurities, and if the internalization ratios of the respective elements exceed 1 wt%, the moldability and corrosion resistance are adversely affected, accompanied by depositions of crude crystals within the material. The internalization ratios of the respective elements are therefore limited to 1 wt% or less. If Cu, Mg, Cr, Zr, and/or Ni are added together with Mn, an effect of improving the moldability of the material at a high temperature is achieved. When their addition ratios are below their respective lower limits, their effects become insufficient, whereas when they exceed their respective upper limits, the moldability may deteriorate. In any event, these elements may entail slight corrosion resistance losses depending on application environments, and therefore, to add them or not should be adventitiously determined. Other elements which have migrated during a manufacturing process do not adversely affect the performances of the material of the present invention so long as their respective ratios are 0.5 wt% or below. Incidentally, the clad material of the present invention can be manufactured by an ordinary method.

[0007]
(Application examples)

In the following, application examples of the present invention will be explained. Core material and skin material alloys characterized by the chemical compositions shown in Table I were each obtained as a cast mass with a thickness of 400 mm and a width of 2,300 mm based on the DC casting method. In the case of a skin material, this cast mass was subjected to a 600°C x 8 hr homogenizing treatment after both of its planes were shaved by 5 mm each, and after it was subsequently hot-rolled and then cold-rolled, a 10 mm sheet material was obtained. In the case of a core material, both planes of the cast mass were shaved by 5 mm each, and after it was joined with a corresponding skin material, the obtained 400 mm laminate material was subjected to a (440 x 6 hr + 520 x 8 hr) homogenizing treatment, and after it was subsequently hot-rolled by an ordinary method, it was cold-rolled, as a result of which a clad material with a thickness of 1 mm was obtained, and after this sheet material had subsequently been annealed at 500°C for 10 sec., a sample material was obtained. As far as comparative examples are concerned, furthermore, in the case of a non-clad material, a 380 mm plane-shaved cast mass was homogenized, hot-rolled, cold-

rolled, and annealed according to procedures identical to those for its clad counterpart, as a result of which a sample sheet material with a thickness of 1 mm was obtained. After a 400 x 400 mm test piece was processed from the obtained sheet material, it was subjected to a hot-roll molding extension test. Said hot-roll molding extension test was conducted by using a 200 mmϕ sphere-headed punch, and the critical molding height unaccompanied by cracks was calculated at a molding temperature of 450°C. The molding rate was designated at 1 mm/sec. in terms of the punch displacement speed. The extent of the color change of the surface of the molded material, furthermore, was checked by naked eye observation. The results are shown in Table I. After a tensile test piece was processed from each sample material, furthermore, it was heated at 450°C for 5 min. for simulating the heating environment of a high-temperature molding operation, and after the temperature had subsequently been lowered to normal temperature, its post-heating strengths were evaluated in a tensile test. The obtained results are also shown in Table I.

[0008]

Table I

	No.		Chemical composition (wt%)											Extension height	Post-heating physical appearance	Post-heating strength	
			Mg	Cu	Zn	Cr	Mn	Zr	Ti	Fe	Ni	Si	Ai			Tensile strength	Pressure resistance
Example of the present invention	1	Core material	4.5	-	-	-	-	-	0.001	0.02	-	0.03	Bal-ance	87	No color change	29.6	14.2
		Skin material	-	-	-	-	1.20	-	-	0.14	-	0.07					
	2	Core material	6.2	-	0.29	-	-	0.13	0.029	0.08	0.32	0.17	"	95	No color change	35.2	16.7
		Skin material	-	-	-	-	1.20	-	-	0.14	-	0.07	"				
	3	Core material	2.0	0.35	-	0.12	0.65	-	0.022	0.18	-	0.10	"	74	No color change	27.8	8.9
		Skin material	1.2	0.64	-	0.25	2.17	0.12	-	0.22	0.27	0.10	"				
	4	Core material	5.2	-	-	0.15	-	-	0.018	0.05	-	0.06	"	90	No color change	32.3	18.2
		Skin material	-	0.45	-	-	0.29	-	-	0.13	1.2	0.08	"				
	5	Core material	4.9	0.42	2.1	0.15	-	0.12	0.012	0.10	-	0.11	"	89	No color change	33.5	18.9
		Skin material	-	-	-	-	1.20	-	-	0.14	-	0.07	"				
Comparative example	6	Core material	4.5	-	-	-	-	-	0.001	0.02	-	0.03	"	87	Color change of entire surface into dark brown	30.9	15.4
		Skin material	No clad														
	7	Core material	0.2	0.33	2.0	-	0.52	-	0.010	0.18	-	0.09	"	52	No color change	11.6	6.2
		Skin material	-	0.45	-	-	0.05	-	-	0.13	1.2	0.08	"				
Comparative Example	8	Core material	9.9	-	-	-	-	-	0.010	0.10	-	0.07	"	63	No color change	38.6	21.9
		Skin material	-	0.45	-	-	0.29	-	-	0.13	1.2	0.08	"				
	9	Core material	4.9	0.42	2.1	0.15	-	0.12	0.012	0.10	-	0.11	"	88	Color change of entire surface into brown	34.1	19.7
		Skin material	2.7	0.65	0.11	0.12	0.44	-	-	0.17	-	0.11	"				
	10	Core material	2.0	0.35	-	0.12	0.65	-	0.022	0.18	-	0.10	"	72	No color change	27.8	8.9
		Skin material	-	-	-	-	2.80	0.20	-	1.43	1.3	2.29	"				

[0009]

As the table clearly indicates, the aluminum alloy clad material of the present invention is unaccompanied by color changes even when a high-temperature molding operation is carried out, which can be contrasted with the comparative materials, and it also exhibits excellent hot-roll moldability and post-heating corrosion resistance.

[0010]

(Effects of the invention)

Not only can excellent hot-roll molding processibility and high post-processing strength be achieved in the present invention, but it is also unaccompanied by such inconveniences as post-processing surface color changes, etc., and thus promises immense industrial effects.

Patent Abstracts of Japan

PUBLICATION NUMBER : 05025573
PUBLICATION DATE : 02-02-93

APPLICATION DATE : 19-07-91
APPLICATION NUMBER : 03204738

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INT.CL. : C22C 21/00 B23K 20/04 C22C 21/06

TITLE : HIGH STRENGTH ALUMINUM ALLOY CLAD MATERIAL FOR HIGH TEMPERATURE FORMING

ABSTRACT : PURPOSE: To obtain an aluminum alloy clad material suitable for a product member used in a marine atmosphere, such as ships, excellent in high temp. formability, and having superior strength.

CONSTITUTION: The material is a high strength aluminum alloy clad material for high temp. forming in which an Al alloy containing, by weight, 0.5-7.5% Mg and also containing one or ≥2 elements among Cr, Mn, Zr, Ti, Fe, Ni, Cu, and Zn as selective elements is used as a core material and an Al alloy containing 0.1-2.5% Mn, ≤1% Fe, and ≤1% Si and also containing one or ≤2 elements among Mg, Cu, Cr, Zr, and Ni as selective elements is used as a cladding material and one side or both sides of the core material are clad with the cladding material.

(19)日本国特許庁（ＪＰ）　(12) 公開特許公報 (A)　(11)特許出願公開番号

特開平5－25573

(43)公開日　平成5年(1993)2月2日

(51)Int.Cl.5	識別記号	庁内整理番号	F I	技術表示箇所
C22C 21/00	E	8928－4K		
B23K 20/04	D	8823－4E		
C22C 21/06		8928－4K		

審査請求　未請求　請求項の数4（全 5 頁）

(21)出願番号　特願平3－204738

(22)出願日　平成3年(1991)7月19日

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(54)【発明の名称】　高温成形用高強度アルミニウム合金クラッド材

(57)【要約】

【目的】　船舶等の海洋性雰囲気において使用される製品部材に好適な高温成形性に優れ、かつ強度に優れたアルミニウム合金クラッド材。

【構成】　心材としてＭｇをwt％で０．５～７．５％を含み、選択元素として、Ｃｒ、Ｍｎ、Ｚｒ、Ｔｉ、Ｆｅ、Ｎｉ、Ｃｕ、Ｚｎの１種または２種以上を含むＡｌ合金とし、皮材としてＭｎ０．１～２．５％、Ｆｅ≦１％、Ｓｉ≦１％含み、選択元素としてＭｇ、Ｃｕ、Ｃｒ、Ｚｒ、Ｎｉの１種または２種以上を含むＡｌ合金とし、心材の片面もしくは両面にクラッドした高温成形用高強度アルミニウム合金クラッド材。

【特許請求の範囲】

【請求項1】　必須元素としてMg０．５～７．５wt％を含有し、さらにCr０．０３～０．５５wt％、Mn０．０３～２．５wt％、Zr０．０３～０．２５wt％、Ti０．００５～０．３５wt％、Fe０．０３～０．５wt％、Ni０．０３～１．５wt％の内１種もしくは２種以上を選択的に含有し、残部がAlから成る心材の片面もしくは両面に、Mn０．１～２．５wt％、Si≦１wt％、Fe≦１wt％、残部がAlからなる皮材をクラッドしたことを特徴とする高温成形用高強度アルミニウム合金クラッド材。

【請求項2】　必須元素としてMg０．５～７．５wt％を含有し、さらにCr０．０３～０．５５wt％、Mn０．０３～２．５wt％、Zr０．０３～０．２５wt％、Ti０．００５～０．３５wt％、Fe０．０３～０．５wt％、Ni０．０３～１．５wt％の内１種もしくは２種以上を選択的に含有し、残部がAlから成る心材の片面もしくは両面に、Mn０．１～２．５wt％、Si≦１wt％、Fe≦１wt％を含み、かつCu０．１～１wt％、Mg０．１～２wt％、Cr０．１～１．０wt％、Zr０．１～０．３wt％、Ni０．１～１．５wt％の内１種もしくは２種以上を選択的に含有し、残部がAlからなる皮材をクラッドしたことを特徴とする高温成形用高強度アルミニウム合金クラッド材。

【請求項3】　必須元素としてMg０．５～７．５wt％を含有し、かつCu０．０１～０．５wt％、Zn０．０２～２．５wt％の内何れか１種もしくは２種を含有し、さらにCr０．０３～０．５５wt％、Mn０．０３～２．５wt％、Zr０．０３～０．２５wt％、Ti０．００５～０．３５wt％、Fe０．０３～０．５wt％、Ni０．０３～１．５wt％の内１種もしくは２種以上を選択的に含有し、残部がAlから成る心材の片面もしくは両面に、Mn０．１～２．５wt％、Si≦１wt％、Fe≦１wt％、残部がAlからなる皮材をクラッドしたことを特徴とする高温成形用高強度アルミニウム合金クラッド材。

【請求項4】　必須元素としてMg０．５～７．５wt％を含有し、かつCu０．０１～０．５wt％、Zn０．０２～２．５wt％の内何れか１種もしくは２種を含有し、さらにCr０．０３～０．５５wt％、Mn０．０３～２．５wt％、Zr０．０３～０．２５wt％、Ti０．００５～０．３５wt％、Fe０．０３～０．５wt％、Ni０．０３～１．５wt％の内１種もしくは２種以上を選択的に含有し、残部がAlから成る心材の片面もしくは両面に、Mn０．１～２．５wt％、Si≦１wt％、Fe≦１wt％を含み、かつCu０．１～１wt％、Mg０．１～２wt％、Cr０．１～１．０wt％、Zr０．１～０．３wt％、Ni０．１～１．５wt％の内１種もしくは２種以上を選択的に含有し、残部がAlからなる皮材をクラッドしたことを特徴とする高温成形用高強度アルミニウム合金クラッド材。

【発明の詳細な説明】

【０００１】

【産業上の利用分野】本発明は、高温成形により成形され、その後表面処理を施される、或いは施されずに使用される材料に好適な、成形性および強度に優れたアルミニウム合金クラッド材に関するものであり、特に船舶等の海洋性雰囲気において使用される製品部材に好適なものである。

【０００２】

【従来の技術とその課題】船舶、特に比較的小型の漁船、レジャーボート等の船体外板には鋼板をプレス成形した後、塗装が施されて使用される場合が多かった。しかし鋼板は塗装の傷、剥離後の耐食性が低く、定期的な再塗装が必要であったために、近年ではFRP製の船体を採用した船舶が急増している。しかしながらこれらFRP製の船体は船としての寿命が過ぎた後のスクラップ処理が困難であるために、海辺等への廃船の放置による環境汚染問題が顕在化している。

【０００３】

【発明が解決しようとする課題】前述のような背景にあって、これら船舶の船体構造材として、鋼板より耐食性に優れ、かつFRPよりスクラップ処理・リサイクル製に優れるアルミニウム板材が注目を浴びている。このような海洋性雰囲気に晒される構造部材には、耐食性と強度・成形性に優れたAl－Mg系の合金が使用される場合が多い。一方、アルミニウム構造材は一般的に鋼板よりも成形性が劣る傾向があり、製品の形状を決定する際の障害となっている。そこで、より複雑な形状にアルミニウム板材を成形する技術として、温間成形あるいは高温成形が検討されている。この技術は、材料および金型の一部もしくは全体を１００～５００℃に加熱して、材料の成形性を高めた条件で成形加工を行うものであり、高加工を要求される部材の成形に好適な技術である。さらにこの高温成形においても、通常のプレス加工の他に、空圧あるいは液圧を使用するバルジ成形も検討されている。この方法によれば、加圧媒体として空圧もしくは液圧を使用するため金型が不要になり、かつ材料が均一に変形していくために成形限界が向上する等のメリットがある。しかしながら前述のAl－Mg系合金に高温成形を行った場合には、表面にMg原子の濃化および酸化が生じて、緑がかった黒色を呈し外観上好ましくない。また塗装を施す場合においても、この酸化層が塗膜密着性を低下させるため、結果として製品の耐食性を劣化させる。この様な酸化皮膜は化学的、機械的に除去する必要があり、生産性を妨げる要因となっていた。この酸化皮膜の生成は温度、加工時間により影響されるが、成形速度が比較的小さい、油圧プレスによるプレス成形あるいはバルジ加工において特に問題となる場合が多い。本発明はこれら問題に鑑み、高温で成形される比較

的小型の船舶の外板等の部材へ使用されるに適する高温成形用高強度アルミニウム合金クラッド材を開発したものである。

【0004】

【課題を解決するための手段】必須元素としてMg0．5～7．5wt％を含有し、さらにCr0．03～0．55wt％、Mn0．03～2．5wt％、Zr0．03～0．25wt％、Ti0．005～0．35wt％、Fe0．03～0．5wt％、Ni0．03～1．5wt％の内1種もしくは2種以上を選択的に含有し、残部がAlから成る心材の片面もしくは両面に、Mn0．1～2．5wt％、Si≦1wt％、Fe≦1wt％、残部がAlからなる皮材をクラッドしたことを特徴とする高温成形用高強度アルミニウム合金クラッド材を請求項1とし、必須元素としてMg0．5～7．5wt％を含有し、さらにCr0．03～0．55wt％、Mn0．03～2．5wt％、Zr0．03～0．25wt％、Ti0．005～0．35wt％、Fe0．03～0．5wt％、Ni0．03～1．5wt％の内1種もしくは2種以上を選択的に含有し、残部がAlから成る心材の片面もしくは両面に、Mn0．1～2．5wt％、Si≦1wt％、Fe≦1wt％を含み、かつCu0．1～1wt％、Mg0．1～2wt％、Cr0．1～1．0wt％、Zr0．1～0．3wt％、Ni0．1～1．5wt％の内1種もしくは2種以上を選択的に含有し、残部がAlからなる皮材をクラッドしたことを特徴とする高温成形用高強度アルミニウム合金クラッド材を請求項2とし、必須元素としてMg0．5～7．5wt％を含有し、かつCu0．01～0．5wt％、Zn0．02～2．5wt％の内何れか1種もしくは2種を含有し、さらにCr0．03～0．55wt％、Mn0．03～2．5wt％、Zr0．03～0．25wt％、Ti0．005～0．35wt％、Fe0．03～0．5wt％、Ni0．03～1．5wt％の内1種もしくは2種以上を選択的に含有し、残部がAlから成る心材の片面もしくは両面に、Mn0．1～2．5wt％、Si≦1wt％、Fe≦1wt％、残部がAlからなる皮材をクラッドしたことを特徴とする高温成形用高強度アルミニウム合金クラッド材を請求項3とし、必須元素としてMg0．5～7．5wt％を含有し、かつCu0．01～0．5wt％、Zn0．02～2．5wt％の内何れか1種もしくは2種を含有し、さらにCr0．03～0．55wt％、Mn0．03～2．5wt％、Zr0．03～0．25wt％、Ti0．005～0．35wt％、Fe0．03～0．5wt％、Ni0．03～1．5wt％の内1種もしくは2種以上を選択的に含有し、残部がAlから成る心材の片面もしくは両面に、Mn0．1～2．5wt％、Si≦1wt％、Fe≦1wt％を含み、かつCu0．1～1wt％、Mg0．1～2wt％、Cr0．1～1．0wt％、Zr0．1～0．3wt％、Ni0．1～1．5wt％の内1種もしくは2種以上を選択的に含有し、残部がAlからなる皮材をクラッドしたことを特徴とする高温成形用高強度アルミニウム合金クラッド材を請求項4とするものである。

【0005】

【作用】本発明において合金成分を限定した理由を以下に説明する。まず心材の合金組成について述べる。Mgは材料中に固溶して、材料の強度および延性を向上することにより成形性を向上させる効果を有する。特に高温に加熱された場合においては材料の成形加工時に均一変形を促進する効果があり、その結果として成形限界が向上する。また製品としての静的な強度を増大して、外的な力による変形を防止し、かつ船体等が外圧を長時間にわたって受けた場合における経時変化（クリープ変形等）を防止する効果もある。さらに本発明が意図した製品が環境要因等により皮材に傷等が生じた場合の素材の耐食性を向上させる効果もある。添加量が0．5wt％未満ではこれら効果が充分ではなく、7．5wt％を越えると材料中に粗大なAl－Mg系化合物を生じて成形性、耐食性を劣化させる。CuおよびZnはMgと共に微細な化合物を材料中に生じることにより、材料の強度および延性を向上することにより成形性を向上させる効果を有する。しかし両元素共に素材の耐食性は若干低下させる傾向があり、心材の耐食性が問題となるような製品においては、その形状および使用環境を考慮したうえで添加あるいは無添加を決定することが好ましい。添加量がそれぞれの下限以下では成形性の向上効果があまり期待出来ず、また上限をこえて添加されると耐食性が著しく低下する。Cr、Mn、Zr、Ti、Fe、NiはそれぞれAlと共に微細な化合物を材料中に生じて、材料組織を微細化して強度および成形性を向上させると共に素材の耐食性も向上させる効果を有する。従ってこれら元素の内から1種もしくは2種以上を選択的に添加すべきである。それぞれ下限未満の添加量ではこれら効果が充分ではなく、上限を越えて添加されると材料中に粗大な化合物を生じて、成形性を劣化させる。上記以外の含有元素については、不純物元素としては主にSiであるが、Siは合金鋳造時にMgと共にMg－Si系の化合物を生じて、Mgの実質的な添加量を減らしてその効果を低減させると共に、耐食性を劣化させるために、その含有量は低い方が好ましい。しかしSi含有量を低下させることは使用地金の高純度化を意味し、これは製造コストの増大につながることから、必要以上にSi含有量を低下させることは工業上好ましくない。これらのことから、Si含有量は0．5wt％以下とすべきである。その他の微量元素についてはそれぞれ0．05wt％以下の含有量であれば本発明の特性に悪影響は及ぼさない。したがって鋳造性改善等の目的で添加される場合があるBe、B等あるいは成形性の向上のために添加される場合があるミッシュメタル等の微量元素は0．05wt％以下の範囲で添加することが可能である。また製造する素材

入する他元素については０．５wt％以下ならば差支えない。

【０００６】次に皮材の合金成分について述べる。皮材は基本的に純Ａｌ系の材料であることが酸化皮膜防止の観点から好ましいが、純Ａｌ系の皮材をクラッドすると材料の強度・成形性が低下する傾向にある。本発明材料においてはクラッドによる強度低下を最小限に抑える為に、高温時の酸化皮膜成長に悪影響を及ぼさず、かつ純Ａｌ系合金により強度の高い皮材としてＡｌ－Ｍｎ系の材料が好適であることを見出した。Ｍｎは常温時の強度向上に有効であるとともに、高温成形時においては材料中に固溶して変形応力の歪み速度感受性指数（ｍ値）を増大させ、その結果として均一変形を促進して成形限界を向上する。さらにＭｎは高温成形時に心材中のＭｇが皮材中に拡散することを抑制する効果があることを本発明者らは見出した。Ｍｎが０．１wt％未満だとこれら効果が十分ではなく、２．５wt％を越えると鋳造中に粗大な晶出物が材料中に生じて、材料の成形性を低下させる危険性が高くなる。ＦｅおよびＳｉは主として不純物として含まれるものであるが、これら元素はそれぞれ１wt％を越えて含有されると、材料中に粗大な晶出物を生じて成形性および耐食性を阻害する。従ってこれら元素の含有量は１wt％以下とする。Ｃｕ、Ｍｇ、Ｃｒ、Ｚｒ、ＮｉはＭｎと共に添加されることにより、材料の高温における成形性を向上させる効果を有する。それぞれ下限未満ではこれら効果が十分ではなく、上限をこえて添加されると逆に成形性を低下させる恐れがある。しかしこれら元素は使用環境においては耐食性を若干低下させる場合があるので、必要に応じて添加、無添加を決定する必要がある。その他製造の際混入する元素は０．５wt％以下であれば本発明材料の特性に悪影響を及ぼさない。なお本発明のクラッド材は常法によって製造することが可能である。

【０００７】

【実施例】以下に本発明の一実施例について説明する。表１の化学組成を有する心材および皮材の合金をＤＣ鋳造により、厚さ４００mm、巾２３００mmの鋳塊とした。皮材はこの鋳塊を両面５mmずつ面削後６００℃×８ｈの均質化処理を施し、その後熱間圧延、冷間圧延にて１０mmの板材とした。心材は鋳塊を両面１０mmずつ面削後、皮材を合わせて４００mmの合わせ材として４４０℃×６ｈ＋５２０℃×８ｈの均質化処理を施し、その後常法により熱間圧延、冷間圧延を行い厚さ１mmのクラッド材とした後、この板材を５００℃×１０sec.の焼鈍処理を施して供試材とした。なお比較例の内、クラッドを施さない材料については面削後の３８０mmの鋳塊をクラッド材と同様に均質化処理、熱間圧延、冷間圧延、焼鈍処理を行って厚さ１mmの供試用板材とした。得られた板材から４００×４００mmの試験片を加工し、温間成形張出し試験に供した。温間成形張出し試験は２００mmφの球頭ポンチを使用して４５０℃で成形し、割れ発生のない成形限界高さを求めた。成形速度はパンチの移動速度で１mm／sec.とした。また成形後の材料表面の変色の度合いを外観目視によりチェックした。結果を表１に併記する。また供試材から引張試験片を加工し、高温成形時の加熱シミュレートとして４５０℃×５min.の加熱を行い常温に冷却した後、加熱後の強度を引張試験により評価した。結果を表１に併記する。

【０００８】

【表１】

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	No		化学組成 (wt%) Mg	Cu	Zn	Cr	Mn	Zr	Ti	Fe	Ni	Si	Al	張出高さ mm	加熱後の外観	加熱後の強度 kgf/mm² 引張強さ	耐力
本発明例	1	心材	4.5	—	—	—	—	—	0.001	0.02	—	0.03	残	87	変色なし	29.6	14.2
		皮材	—	—	—	—	1.20	—	—	0.14	—	0.07	〃				
	2	心材	6.2		0.29	—	—	0.13	0.029	0.08	0.32	0.17	〃	95	変色なし	35.2	16.7
		皮材	—	—	—	—	1.20	-	—	0.14	—	0.07	〃				
	3	心材	2.0	0.35	—	0.12	0.65	—	0.022	0.18	—	0.10	〃	74	変色なし	27.8	8.9
		皮材	1.2	0.64	—	0.25	2.17	0.12	-	0.22	0.27	0.10	〃				
	4	心材	5.2	—	—	0.15	—	—	0.018	0.05	—	0.06	〃	90	変色なし	32.3	18.2
		皮材	—	0.45	—	—	0.29	—	—	0.13	1.2	0.08	〃				
	5	心材	4.9	0.42	2.1	0.15	—	0.12	0.012	0.10	—	0.11	〃	89	変色なし	33.5	18.9
		皮材	—	—	—	—	1.20	—	—	0.14	—	0.07	〃				
比較例	6	心材	4.5	—	—	—		—	0.001	0.02	—	0.03	〃	87	全面が黒褐色に変色	30.9	15.4
		皮材	クラッドなし														
	7	心材	0.2	0.33	2.0	—	0.52	—	0.010	0.18	—	0.09	〃	52	変色なし	11.6	6.2
		皮材	—	0.45	—	—	0.05	—	—	0.13	1.2	0.08	〃				
	8	心材	9.9	—	—	—	—	—	0.010	0.10	—	0.07	〃	63	変色なし	38.6	21.9
		皮材	—	0.45	—	—	0.29	—	—	0.13	1.2	0.08	〃				
	9	心材	4.9	0.42	2.1	0.15	—	0.12	0.012	0.10	—	0.11	〃	88	全面が褐色に変色	34.1	19.7
		皮材	2.7	0.65	0.11	0.12	0.44	—	—	0.17	—	0.11	〃				
	10	心材	2.0	0.35	—	0.12	0.65	—	0.022	0.18		0.10	〃	72	変色なし	27.8	8.9
		皮材	—	—	—	—	2.80	0.20	—	1.43	1.3	2.29	〃				

【0009】表から明らかなように、本発明のアルミニウム合金クラッド材は比較材に比べ高温成形をおこなっても変色もなく、かつ優れた温間成形性および加熱後の優れた耐食性を示すことが分かる。

【0010】

【発明の効果】本発明によれば優れた温間成形加工性と加工後に高い強度を示し、かつ加工後の表面変色等の不具合等のない特徴を有し、工業上顕著な効果を奏するものである。